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Tropical Cyclone Track Objective Aids for the Microcomputer: PCLM, XTRP, PCHP

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ABSTRACT

A Climatology Objective Aid for the microcomputer has been developed which includes a forecast based on climatology (PCLM), a persistence forecast (XTRP), and a half persistence and climatology forecast (PCHP). The climatology is 1945-89 data from the western North Pacific, eastern North Pacific, South Pacific and Indian Oceans. The objective aid has a graphical presentation of the climatological tracks used in the forecast. Results from homogeneous comparisons of forecast errors from the first 18 storms in the western North Pacific during 1989 show that PCLM functions adequately.

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CONTENTS

TROPICAL CYCLONE TRACK OBJECTIVE AIDS FOR THE MICROCOMPUTER: PCLM, XTRP, AND PCHP

1. Background

In a letter to the Joint Typhoon Warning Center (JTWC) Guam, the Commander, Naval Oceanography Command (CNOC) requested that JTWC prioritize tropical cyclone track objective aids and list those that could be discarded from Fleet Numerical Oceanography Center (FNOC) without detriment to the typhoon warning system. The JTWC response was to develop a prioritized list of tropical cyclone track objective aids, but not to single out objective aids for elimination. JTWC recommended that FNOC and the Naval Oceanographic and Atmospheric Research Laboratory (NOARL) convert objective aids to run on a microcomputer whenever possible. Three phases of conversion were identified.

Phase I is the conversion of Climatology (CLIM), Extrapolation (XTRP), and Half Persistence and Climatology (HPAC). Phase II is conversion of Climatology/Persistence (CLIP) and the analogs (TOTL, RECR, and STRA). Phase III is the conversion of the One Way Interactive Tropical Cyclone Model (OTCM), the Colorado State University Model (CSUM), and the Cyclops Objective Steering Model Output Statistics (COSMOS). The final phase can not be completed before the required input field data are routinely available at the regional centers.

The main reason cited by JTWC for converting objective aids to run on a microcomputer is that all the objective aids are of use in some circumstances. Therefore, JTWC would rather convert objective aids to run on a microcomputer than eliminate them. The conversion would allow JTWC to use all of the objective aids while reducing computer load at FNOC.

Additional reasons for the conversion were cited by JTWC in correspondence with CNOC. First, turn around time for the microcomputer versions of objective aids is faster than for those run remotely at FNOC. To run an objective aid at FNOC, JTWC forecasters must call in via modem to initiate the objective aid run and some 15 minutes later they must call back to receive the forecast.

Secondly, objective aids that run on the microcomputer will provide forecast guidance during communications disruptions between JTWC and FNOC. If appropriate objective aids are converted to run on the microcomputer, JTWC operations can continue effectively without guidance from FNOC.

Objective aids converted to the microcomputer can use graphics capabilities for display of input data. When a forecaster is presented with a graphical diagram of the operation of an objective aid, he/she can discern the circumstances that contributed to produce questionable forecasts. For example, the climatology forecast is questionable when the climatology objective aid bases its forecast on a small sample of climatological tracks. The microcomputer climatology forecast aid can present data so that these situations are easily recognized.

For the reasons cited above, NOARL has begun conversion of objective aids to the microcomputer. The objective aids listed in Phase I have been converted to run on a microcomputer and are discussed in this technical note.

2. Forecast aids

This section reviews the specifics of the microcomputer forecast aids Extrapolation (XTRP), PC Climatology (PCLM) and PC Half Persistence and Climatology (PCHP) models. Discussion is limited to the highlights of the objective aids. Differences that exist between the microcomputer and FNOC versions of the forecast aids are discussed.

2.1 XTRP

The XTRP forecast is a linear extrapolation from the 12-hour-old and current positions are computed along a rhumb line. XTRP does not include an intensity forecast and yields exactly the same forecast at FNOC and on the microcomputer.

2.2 PCLM

The microcomputer version of the climatology forecast aid (PCLM) is based on climatology data which currently covers the years 1945-1989. The climatology can be updated to include

more recent data as they become available. This process is discussed in section 6.2. The FNOC version only uses climatology from 1945-1979 and is not easily updated.

The PCLM forecast for a position (hereafter called the current position) is computed using tropical cyclone tracks located the current position during approximately the same time of year. The temporal constraint is that climatological storms must have occurred within +/- 15 days of the Julian date of the current position. This is different from the FNOC version which uses the calendar month of the current position as the temporal restriction. The spatial restriction of the micro-computer version is that climatological storms must have passed within 200 km of the current position. The spatial restriction of the FNOC version is that a storm must pass within a 6° latitude by 6° longitude box centered on the current position.

The PCLM forecast is an average of all the climatological tracks which pass the temporal and spatial restrictions described above. A check is done to find the closest point of approach (CPA) of each climatological track. The tracks are all translated to the current position using the difference in latitude and longitude of the current position and the CPA. Average 24, 48 and 72 hour latitudes and longitudes computed are the forecast positions. The FNOC version is different in the way the forecast is computed. Average tracks are computed at each of the four corners of the aforementioned box. The average of these four tracks is the climatology forecast.

The PCLM intensity forecast is an average of the intensities for the storms which have traveled within the 200 km radius of the current position. The 24, 48 and 72-h intensity forecast are the average of intensities for positions 24, 48 and 72-h after CPA. The FNOC version intensity forecasts are computed for four corners of the box used in the FNOC position forecast.

PCLM includes a graphical representation of the climatology forecast (Fig. 1). The graph-ical representation shows the forecaster how the climatology forecast is computed. The climatolo-gy is color coded to distinguish between 24, 48 and 72-h positions. The graphical display helps the forecaster determine when the forecast is of value and when it is not. For example, the fore-caster can determine the following:

1) How many tropical cyclones since 1945 have passed through the same region as the

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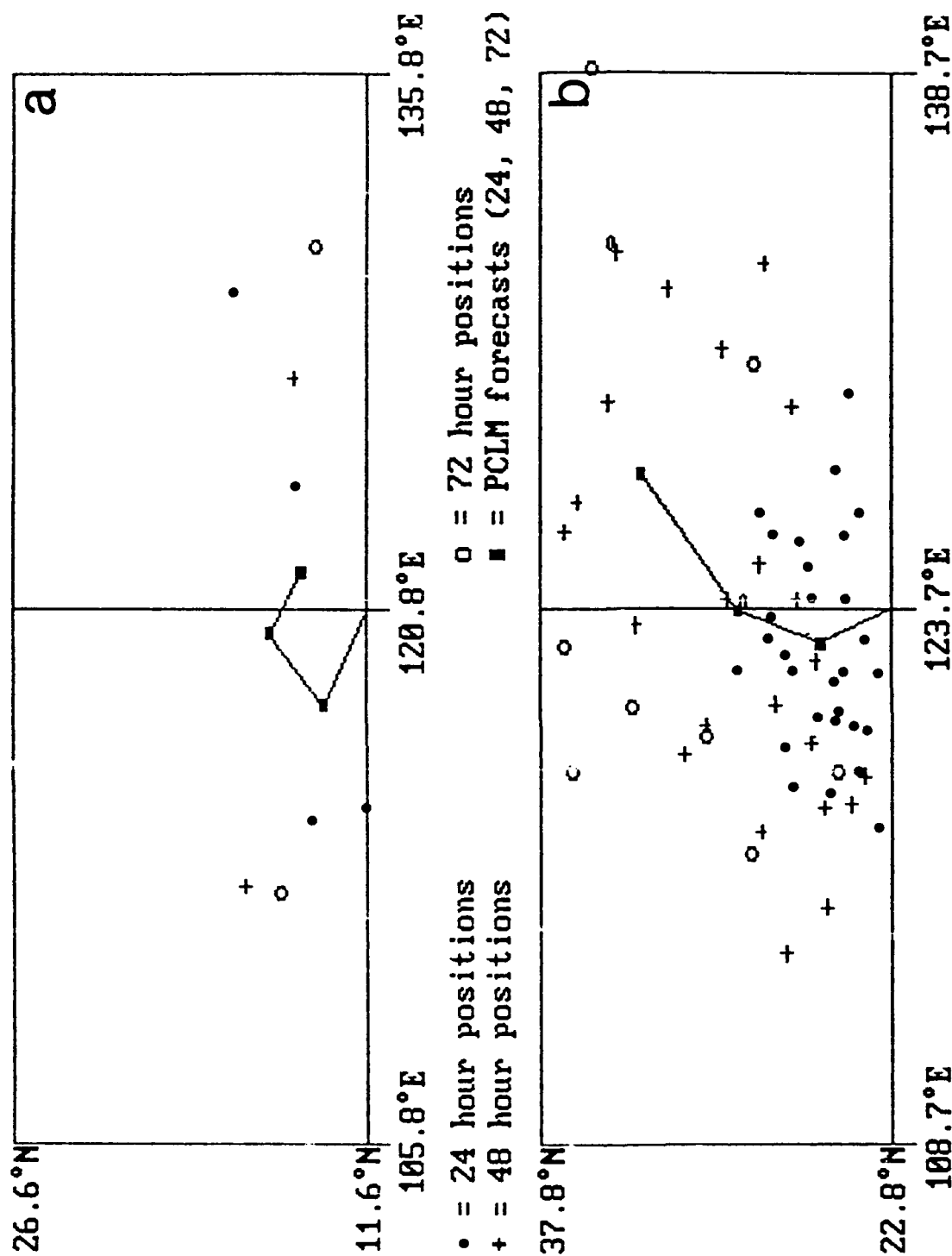
Fig. 1. (a) PCLM forecast (solid line) and climatological positions used in making forecast for a case with few positions. (b) Same as (a) but for a case with many widely dispersed climatological positions. (c) Same as (a) but for a case with many narrowly dispersed positions. (d) Same as (a) but for case with distinct groups of recurving and straight moving storms.

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o = 72 hour positions
■ = PCLM forecasts (24, 48, 72)

139.0°E
124.0°E
109.0°E
17.5°N
32.5°N

• = 24 hour positions
+ = 48 hour positions

d

135.5°E
120.5°E
105.5°E
14.5°N
29.5°N

5
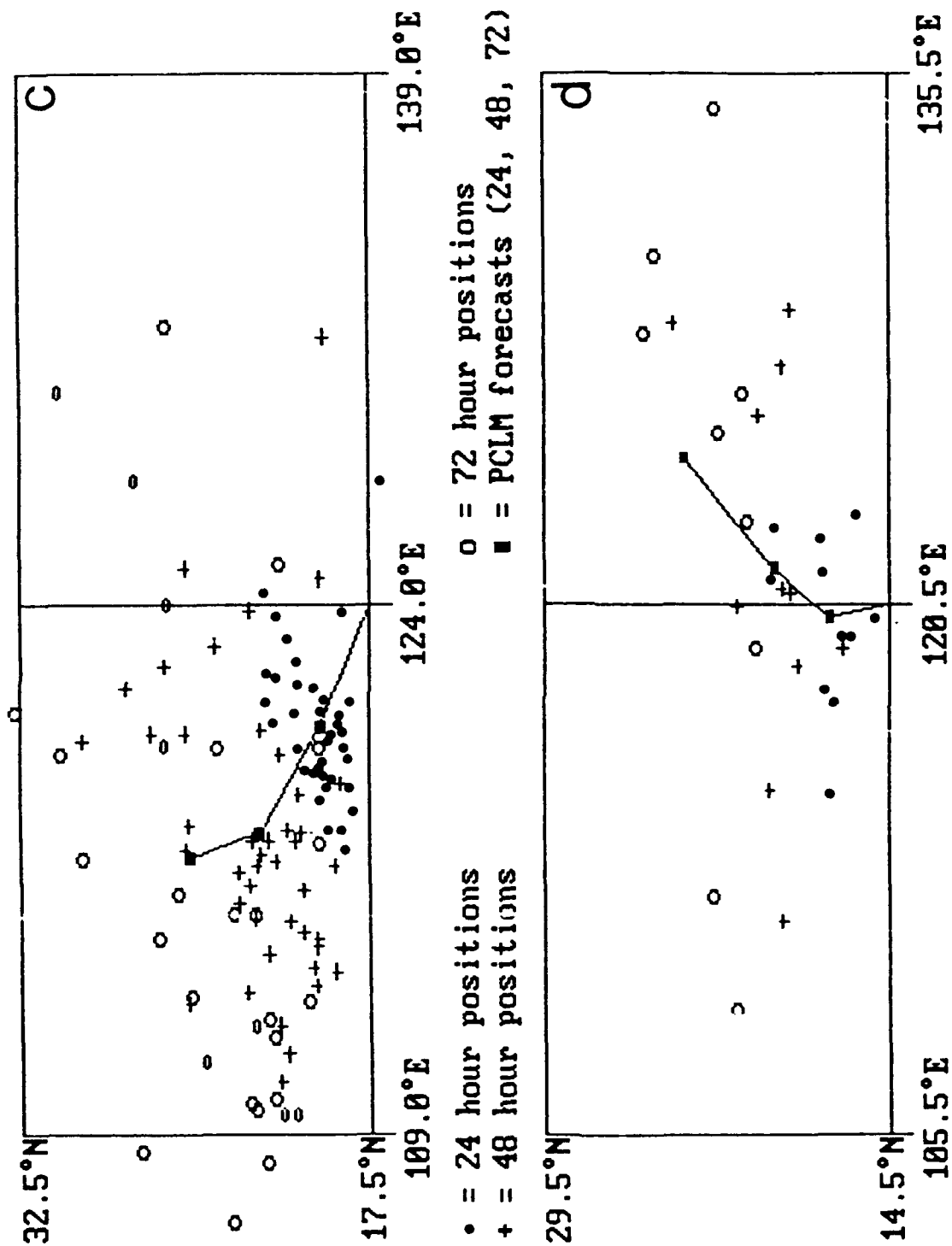
current storm. If very few tropical cyclones have traveled through the region, the PCLM forecast is of questionable value (Fig 1. a).

2) The spatial organization of the climatological tracks. If the climatological tracks are widely scattered, then the climatology forecast may be of little use even though the PCLM forecast looks reasonable (Fig 1. b). Also, if the tropical cyclones traveling through the region are mostly straight moving or slowly recurving cyclones (Fig 1. c) then the forecaster is forewarned that a sharply recurving track is climatologically less probable. In this case, a forecast track which does not reside in the upper left quadrant of the diagram is climatologically anomalous.

3) How well the climatology forecast represents the climatology. In an extreme case, one can envision distinct groups of straight running and sharply recurving climatological tracks. The climatology forecast would bisect the two groups, but would not adequately represent the straight runners or the recurvers. In other words, the PCLM forecast would predict a track that tropical cyclones have rarely traveled (Fig 1. d).

2.3 PCHP

The PCHP position forecast (there is no PCHP intensity forecast) is a linear average of the XTRP and PCLM forecasts. The FNOC version (HPAC) is computed the same way. The forecasts are different because of differences in PCLM and CLIM.

2.4 Homogeneous comparisons

Discrepencies between the PCLM and CLIM models results in different forecasts. Therefore, a homogeneous data set for the first 18 storms of 1989 is used to determine that PCLM functions adequately. The homogeneous data set contains both PCLM and CLIM 72-h forecast positions for each storm position. Forecast error (FTE), the difference between the storm position and the forecast position, is computed for both PCLM and CLIM. Differences in FTE are calculated for each homogeneous pair of PCLM and CLIM forecasts.

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Differences n FTE are generally less than 200 nm although a few fall outside the 200 nm range. These a small number of the total data set (3%). The three forecasts (2% of the total number of forecasts) in which PCLM performed worse than CLIM by greater than 200 nm were investigated. It was found that PCLM forecasts were influenced negatively by storms that occurred after 1979. CLIM forecasts for the same storm positions did not use the post-1979 data and were not adversely affected. One PCLM forecast was 600 nm better than its CLIM counterpart. This PCLM forecast was influenced by the post-1979 climatological tracks. Therefore it is concluded that PCLM functions adequately. The distribution of the FTE differences is shown in Fig. 2.

3. System specifications

The Automated Tropical Cyclone Forecasting system (ATCF) is a microcomputer-based system to aid JTWC forecasters. The ATCF design calls for use of ordinarily available software and hardware. The XTRP, PCLM and PCHP software is designed to be integrated with ATCF, so the design restrictions that apply to ATCF also apply to the microcomputer objective aid software.

The following is a list of minimum hardware and software required for the climatology forecast aid :

Hardware

Zenith 248 or compatible computer
    80286 CPU
    640 K RAM
    20mb Hard disk
    EGA display

Software

MS DOS version 3.2 or compatible operating system
MicroSoft FORTRAN version 5.O or compatible
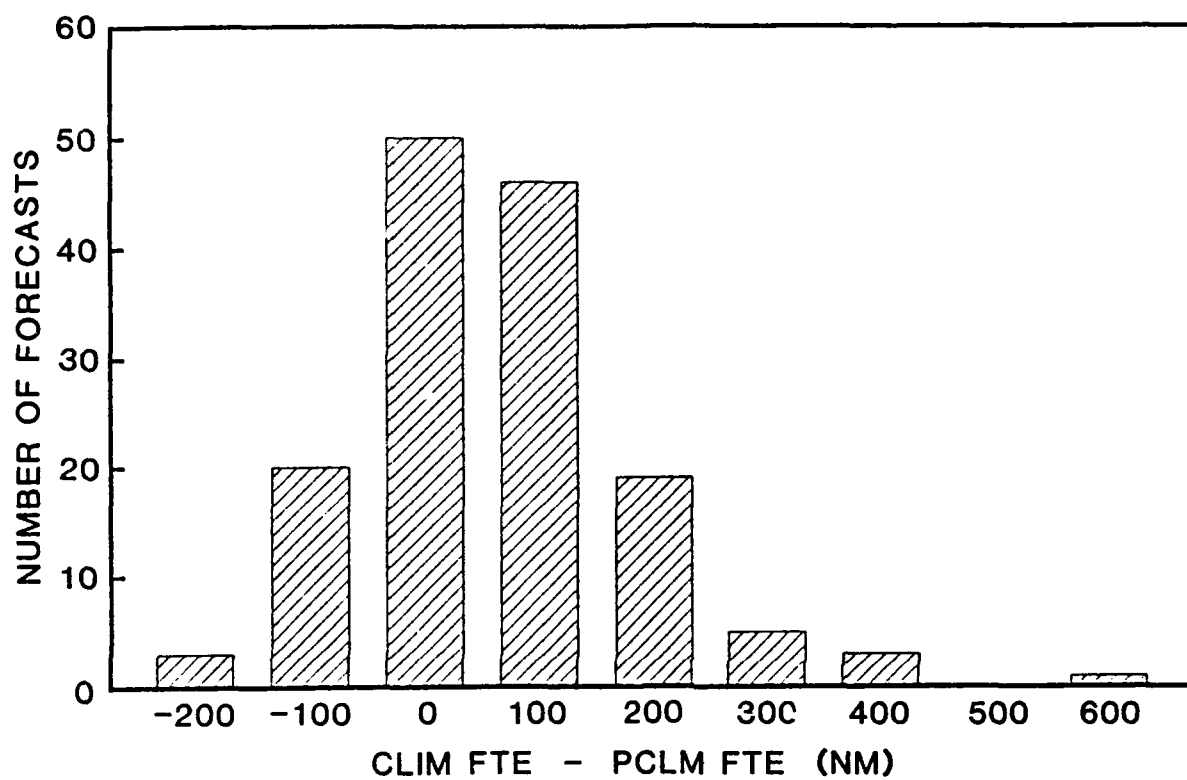compiler (for program modification)

Fig. 2. Homogeneous comparison of differences in 72-h forecast errors for CLIM and PCLM. Differences are grouped into 8 distinct categories with intervals of 100 nm.

4. Data structures

This section describes the stratification of the climatological tropical cyclone tracks into directories and files. The data structures of the climatological forecast aid reflect an attempt to keep the data base maintenance simple yet provide for rapid program execution. The data files are organized so that they are compatible with ATCF software.

4.1 \CLIMO directory

The climatology forecast aid consists of two directories. The primary directory \CLIMO contains all the applications and supplementary data files needed to operate and maintain the climatology objective aid. The following is a list of the files in this directory with a short description of each files function:

addclim.exe - executable program for adding climatology to data base.

addclim.for - source code for adding climatology to data base.

adeck.out - output file containing CARQ positions and XTRP, PCLM and PCHP forecasts.

brennyy.dat - tropical cyclone track data file. These files can be added to the data base or used to produce climatology forecasts. b is the character "b", re is the region of the tropical cyclone, nn is the chronological storm number for the year, yy is the year of the storm.

pc.bat - batch file for running climatological forecast aid.

pclm.exe - executable program for running climatological forecast aid.

pclm.for - source code for running climatological forecast aid.

clidir.lst - listing of all files in \CLIMO\DATE directory. Used by carq.exe.

debug.da' - output file containing debugging information of carq.exe. This file can be used for trouble shooting as it contains a chronological list of the program operation.

techlist.dat - list of objective aids and associated number.

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4.2 \CLIMO\DATE directory

The sub-directory **\CLIMO\DATE** contains the climatological tropical cyclone track data. The western North Pacific Ocean (WP) , Indian Ocean (IO), Southern Hemisphere (SH), and eastern North Pacific Ocean (EP) are combined in a data set stratified by date of the year. The filenames are in the format mmdd.CLI, where mm is the month of year and dd is the day of month. A total of 366 files is possible (365 days/year + Feb 29).

4.3 File formats

The data file formats for files in the **\CLIMO** and **\CLIMO\DATE** directories are described here: (All longitude outputs are in FNOC format)

<u>adeck.out</u>

record #1 : NNNAMEYYMMDDHH LT00LN00 LT12LN12 LT24LN24 V00 V12 SPDIR RECYYR
       NN = Position number: 00
       NAME = Position name: CARQ
       YYMMDDHH = Warning DTG
       LT00, LN00 = Latitude, longitude of current warning position
       LT12, LN12 = Latitude, longitude of 12 hour old position
       LT24, LN24 = Latitude, longitude of 24 hour old position
       V00 = Maximum sustained wind at current warning DTG
       V12 = 12 hour old maximum sustained wind (NOT COMPUTED)
       SPD = Speed of advance of cyclone over the past 12 hours
               (in knots with tenths of knots).
       DIR = Direction of movement over the past 12 hours (1 to 360)
       RECYYR = Storm ID
          RE - region (WP,EP,IO,SH)
          CY - Annual cyclone number
          YR - 2-digit year

record #2-n : NNNAMEYYMMDDHH LT24LN24 LT48LN48 LT72LN72 V12 V24 V48 V72 RECYYR

       NN = Objective Technique number
       NAME = 4 letter acronym for each objective technique

NN	NAME	DESCRIPTION
16	XTRP	Extrapolation from past 12 hours
48	PCLM	Climatology forecast, PC version
49	PCHP	Half Persistence and Climatology, PC version

LT24, LN24 = Latitude, longitude of tau 24 forecast
LT48, LN48 = Latitude, longitude of tau 48 forecast
LT72, LN72 = Latitude, longitude of tau 72 forecast
V12 = Maximum wind at tau 12 (NOT COMPUTED)
V24 = Maximum wind at tau 24
V48 = Maximum wind at tau 48
V72 = Maximum wind at tau 72

RECYYR = Storm ID
      RE - region (WP,EP,CP,IO,SH)
      CY - Annual cyclone number
      YR - 2-digit year

<u>brennyv.dat</u>

CYYYMMDDHH LATIOLONGO VMAX

CY = Annual cyclone number
YYMMDDHH = DTG
LATIO, LONGO = Latitude, longitude position for given DTG.
"O" is the hemispheric index (N/S, E/W)
VMAX = Maximum sustained wind speed
Notes: Best track positions are in 6-hourly increments

<u>techlist.dat</u>

record #1: file header

record #2-n: NUM TECH XXXXXX XXXX XXXXX

NUM = technique number (e.g, XTRP=16, PCLM=48, PCHP=49)
TECH = technique name (e.g, XTRP, PCLM, PCHP)
XXXXXX = not used
XXXX = not used
XXXXX = not used

5. Installation

The climatology objective aid is installed on a hard disk. The data base currently uses over two megabytes of disk space and will grow as the climatology is updated. To install, two directories on your hard disk are created, and the data on the diskettes is copied into the directories:

```
md climo
md climo\date
cd climo
Insert disk #1 into drive a
copy a:*.*
cd date
Insert disk #2 into drive a
copy a:*.*
Insert disk #3 into drive a
copy a:*.*
.
.
.
```

Insert disk #1 / into drive a
copy a:*.*

This completes software installation. Section 6.1 is used to test the software.

6. Program operation

Program operation is divided into two tasks: running the climatology objective aid and updating the climatology data set. In general, the user will only be running the climatology objective aid. Updating the climatology data set will be done annually when the tropical cyclone tracks have been finalized.

6.1 Running climatology objective aid

When the software has been installed on the hard disk, program operation can be checked using the following procedure:

From the \CLIMO directory, type **pc wp1889.**

The program will ask you for the DTG to use in the
climatology forecast.

Enter **<RETURN>** to allow the program
to use the last DTG in the best track data file (bwp1889.dat).

Program operation will now continue for about 6 minutes
(less than one second is devoted to the XTRP, the rest is
devoted to the PCLM forecast).
Listed on the screen are the files that are used to compute
the forecasts.

Finally, the climatology used in the forecast and the fore-
cast itself is displayed graphically on the screen.

Enter **<RETURN>** to compute PCHP (Half Persistence and
Climatology) and terminate the program.

If you now **type adeck.out,** you will see a file with a CARQ line and 3 forecasts (XTRP,
PCLM, and PCHP). See section 4.3 for a detailed description of this file.

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6.2 Updating the climatology

To add a tropical cyclone track to the climatology, a complete tropical cyclone track file must be created (e.g., bwp0190.dat). To integrate the track file into the climatology data base, enter **addclim brennyy.dat** (where b is the character "b", re is the region, nn is the storm number and yy is the year).

7. Summary

CLIM, XTRP and HPAC have been converted to run on the microcomputer. The microcomputer versions (PCLM and PCHP) give different forecasts than their mainframe counterparts. A homogeneous data set of 72-h PCLM and CLIM forecast errors for the first eighteen storms of 1989 was compiled. Results show that PCLM functions adequately. It is hoped that the graphical presentation of the climatology in PCLM will aid in tropical cyclone forecasting at JTWC.

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